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(71) Applicant: **State of Israel Ministry of Defence
Raphael Armament Development Authority
P.O. Box 2250
Haifa (IL)**

(72) Inventor: **Maytal, Ben-Zion
43 Netiv Hakramin Street
Atlit 30300 (IL)**

(74) Representative: **Perani, Aurelio et al
c/o JACOBACCI & PERANI S.p.A
Via Visconti di Modrone, 7
I-20122 Milano (IT)**

(54) **Controlled cryogenic contact system.**

(57) An apparatus for creating controlled temperature changes on a contact surface, comprises: a) a probe having a contact surface, which probe is suitable for creating fast temperature changes at the said contact surface; b) temperature generation means, coupled to the said probe, being capable of creating cryogenic and above 0°C temperatures at the said contact surface of the said probe; and c) processing means to control the said temperature generation means according to predetermined operating conditions.

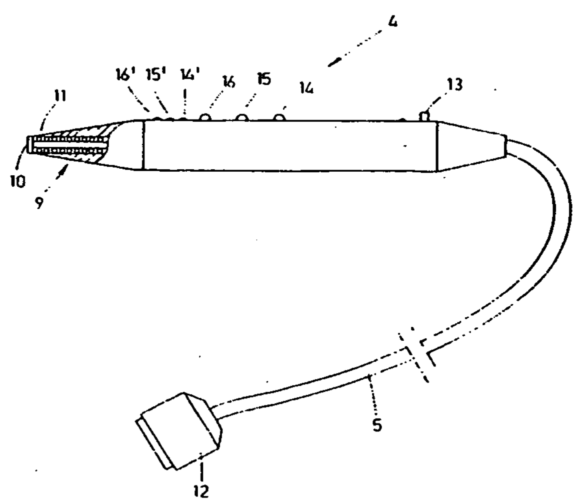

Fig. 2

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the invention, since processes and devices employing a one-pass heating or cooling, without utilizing an exchange of heat via an appropriate heat-exchanger, will not provide sufficiently low or sufficiently high temperatures, and will result in a temperature change which is excessively slow.

Heat exchangers can be of any type, and may be, e.g., a finned tube heat-exchanger of a porous-matrix heat-exchanger, e.g., of the type described in British Patent No. 1,422,445. The device described in this British patent provides only for the cryocooling of the probe, the purpose being to maintain the temperature of the probe below -80°C, thus avoiding altogether the need for heating the probe. It should be mentioned that, according to the teachings of this patent, heating was necessary, when operating at temperatures above -80°C, for the purpose to prevent the probe from sticking to the tissue. However, when operating according to IL 104506, with fast cooling-heating cycles, the heat exchanger can be utilized also for heating purposes.

The first gas is preferably selected from the group consisting essentially of argon, nitrogen, air, krypton, CF_4, xenon and N_2O, and the second gas is helium.

Cryogenic liquefaction occurs at the tip of the cold extremity of the device operating according to IL 104506, under the cooled metal surface. The Linde-Hampson method is applied, using the Joule-Thomson effect for cooldown to liquefaction.

IL 104506 also describes an apparatus for the cryocooling and the heating of surfaces, comprising:

1) a heat exchanger coupled to an orifice, the said orifice opening into a jacket;
2) a jacket which is in contact with the surface to be heated and cooled, the said jacket forming a reservoir capable of housing a fluid in contact with the surface to be heated and cooled;
3) two pressurized gas sources, each gas source being independently connected to the said heat exchanger;
4) means for allowing and stopping the flow of each gas through the said orifice.

The method of IL 104506 makes it possible to obtain a high frequency of temperature change. Thus, for instance, one may which, for a given application, to oscillate between temperatures of -50°C and + 100°C only.

SUMMARY OF THE INVENTION

It has now been found, and this is an object of the present invention, that it is highly advantageous to be able to control the operation of the heating/cooling device the temperature of which changes rapidly, for a variety of uses and applications.

It is an object of the present invention to provide an apparatus which permits to control the temperature obtained on the contact surface of a probe in which heating and cooling is achieved by the Joule-Thomson effect obtained through the expansion of gases.

It is another object of the invention to provide an apparatus which can be easily operated by unskilled operators while providing highly precise and controlled temperatures.

It is still another object of the invention to provide an apparatus which can be pre-programmed to create desired temperature changes with time in an appropriate probe.

It is still a further object of the invention to provide a relatively inexpensive, easy to use and convenient to operate apparatus of the type described above. Other objects of the invention will become apparent as the description proceeds.

The apparatus for creating controlled temperature changes on a contact surface, according to the invention, comprises:

a) a probe having a contact surface, which probe is suitable for creating fast temperature changes at the said contact surface;
b) temperature generation means, coupled to the said probe, being capable of creating cryogenic and above 0°C temperatures at the said contact surface of the said probe; and
c) processing means to control the said temperature generation means according to predetermined operating conditions.

The temperature generation means can be of any suitable type, including but not limited to gas expansion, electric means, and their combinations. According to a preferred embodiment of the invention the apparatus comprises:

a) a probe comprising:
    1) heat exchanging means coupled to an orifice, the said orifice opening into a jacket;
    2) a jacket which is in contact with the surface to be heated and cooled, the said jacket forming a reservoir capable of housing a fluid in contact with the surface to be heated and cooled;
    3) two independent connections for pressurized gas sources, connected to the said heat exchanger;
b) two independent pressurized gas sources, connected to the said probe through the said two independent connections;
c) controllable gas flow valves to permit or preclude the flow of each of the gases from the said independent pressurized gas sources into the said probe;
d) processing means to control the said controllable gas flow rate valves according to predeter-

in the experiment described in Example 2.

Detailed Description of Preferred Embodiments

Fig. 1 illustrates a device according to a preferred embodiment of the invention. This device is designed to be movable and self-supporting, and does not require connection to outside gas sources. It consists of a body 1, provided with wheels 2, which houses two gas reservoirs (not shown). The reservoirs can be replaced through the backdoor, which is not seen in the figure. An additional door 3 gives access to the inside of the body, and is used for parts replacement and maintenance, as well as for housing spare parts.

A probe 4 is connected to the gas reservoirs and to a microprocessor, as explained above and in further detail below, through line 5. All connections are within body 1. A keyboard 6 and a display 7 are provided on the front panel of the apparatus, along with on-off switch 8 control lights 8' and 8", which can be used to indicate the operation status of the apparatus, e.g., to indicate at any given time whether it is cooling or heating.

Since the electric power requirements of the apparatus are relatively very low, the apparatus is powered by a DC source, such as a battery, but may alternatively be connected to an AC source.

Fig. 2 shows the probe 4 of Fig. 1 in greater detail. The Joule-Thomson heat exchanger 9 serves contact surface 10, which is heated or cooled, depending on the nature of the gas flowing therethrough. Thermocouple 11 is in close contact with the inner part of contact surface 10, and detects the temperature at that location. The thermocouple wire is led to the processing means through line 5 and connector 12. leaving the probe is exhausted to the atmosphere either through connections in the probe, or at connector 12.

The probe is provided with a main switch 13, operating switches 14, 15 and 16, and monitor lights 14', 15' and 16'. These switches operate the probe towards cooling or heating, or for preset cooling/heating cycles, and the lights indicate the operation being performed. Manual operation or microprocessor-controlled operation can be chosen.

Looking now at Fig. 3, a central processing unit (CPU) controls the operation of the apparatus, according to predetermined operating conditions provided to it. Programming of the operating conditions can be made through keyboard 6 of Fig. 1 (indicated by KB in the figure), or through a communication port CP, connected to a programming computer, or through a data reader DR, e.g., a magnetic or optical reader. The data can be displayed on a display, e.g., a liquid crystal display (LCD), and the keyboard can be used also to read data from the CPU and to display them on the LCD. The CPU can be provided with a substantial memory, so as to store not only operating parameters to be controlled, but also data received during the operation, e.g., temperature or pressure readings.

Data contained in the memory of the CPU can be printed out, e.g., through an RS232 or similar port.

Line 5 of probe 4 contains two incoming gas lines, 17 and 18, as well as an outgoing thermocouple line 19, the readings of which are fed to the CPU. In response, and in order to maintain the preprogrammed temperature in the probe contact surface, the CPU operates the two controllable valves 20 and 21, which control the flow of gas into the probe 4. Two pressure gauges, 22 and 23, provide pressure readings to the CPU, which relate to the pressure in reservoirs 24 and 25.

Example 1

An apparatus was built according to the embodiment described above. It included E-type thermocouples, a 18 mm diameter probe, with a length of 160 mm. The gases employed where argon (for cooling) and helium (for heating). The diameter of the contact surface of the probe was 6 mm.

In order to test the controllability of the apparatus, the temperatures range was set around a single temperature at a given time, and three different temperatures were tested. these were -140°C, -120°C and -80°C. Each temperature was maintained for 5 minutes, as seen in Fig. 4 which shows the thermocouple readings (11 in Fig. 2) for this experiment. It can be seen that the apparatus of the invention is capable of maintaining a virtually constant temperature, by alternating two different gases with a high frequency.

Example 2

The apparatus of Example 1 was used in an experiment in which it was desired periodically to cool a surface to cryogenic temperature (-165°C) and then to above-zero temperature (44°C), the frequency of oscillation between the two extreme temperatures being required to be 38 seconds. These data were fed to the CPU, which was preprogrammed accordingly. The details of the computer program are not given herein for the sake of brevity, since providing an appropriate program is within the scope of the routineer.

The specimen on the surface of which the probe was applied was a potato. The resulting temperature readings at the contact surface are shown in Fig. 5. Additional temperature readings

and

e) controlling the temperature of the contact surface of the probe to obtain the said desired temperature values and/or profiles by controlling, by means of the said processing means, the activity of the said negative and of the said positive temperatures generating means.

13. A method according to claim 12, comprising:

a) providing a probe comprising:

1) heat exchanging means coupled to an orifice, the said orifice opening into a jacket;

2) a jacket which is in contact with the surface to be heated and cooled, the said jacket forming a reservoir capable of housing a fluid in contact with the surface to be heated and cooled;

3) two independent connections for pressurized gas sources, connected to the said heat exchanger;

b) providing two independent pressurized gas sources, connected to the said probe through the said two independent connections;

c) providing controllable gas flow valves to permit or preclude the flow of each of the gases from the said independent pressurized gas sources into the said probe;

d) providing processing means and programming them to control the said controllable gas flow rate valves according to predetermined operating conditions.

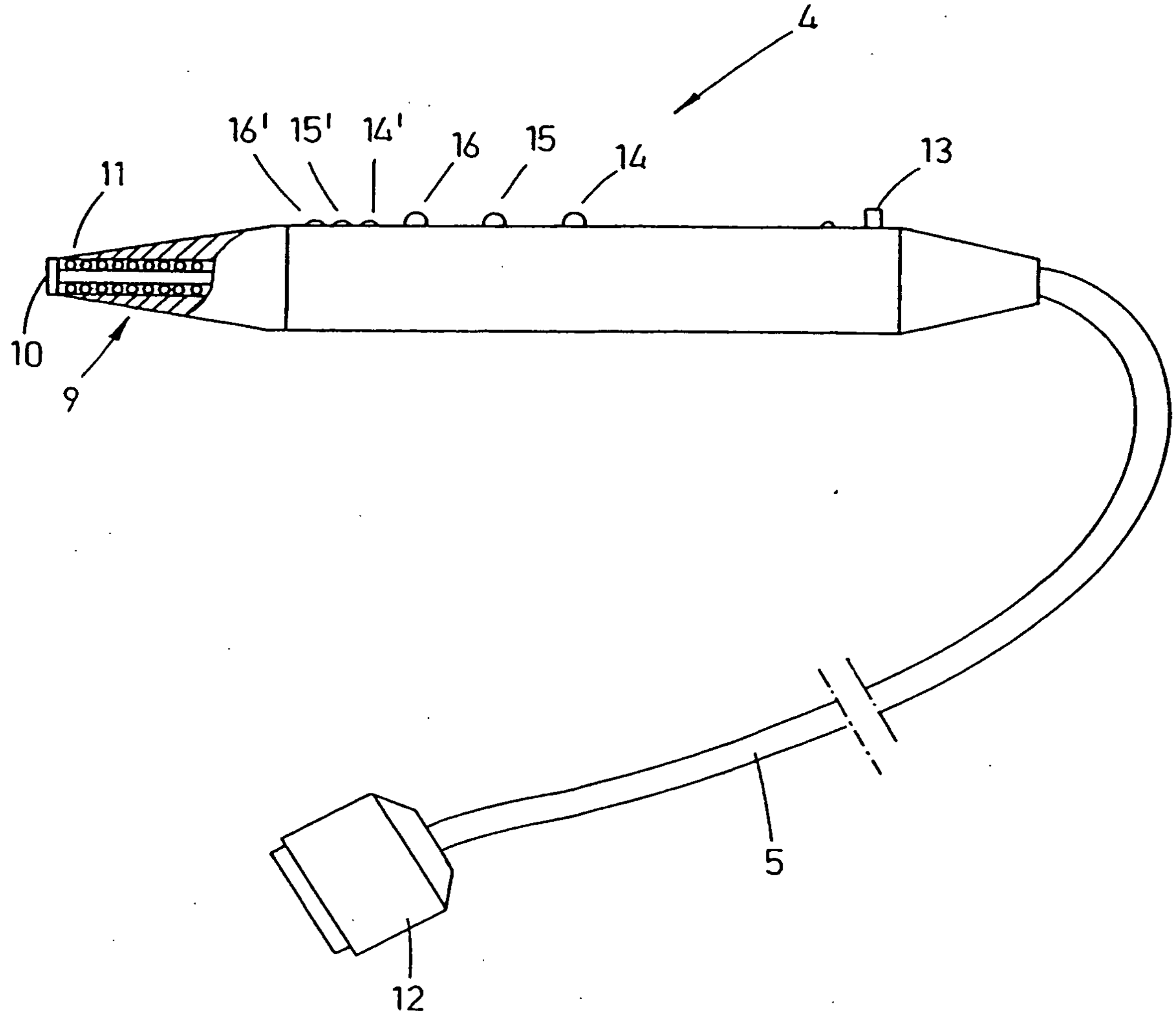

Fig. 2

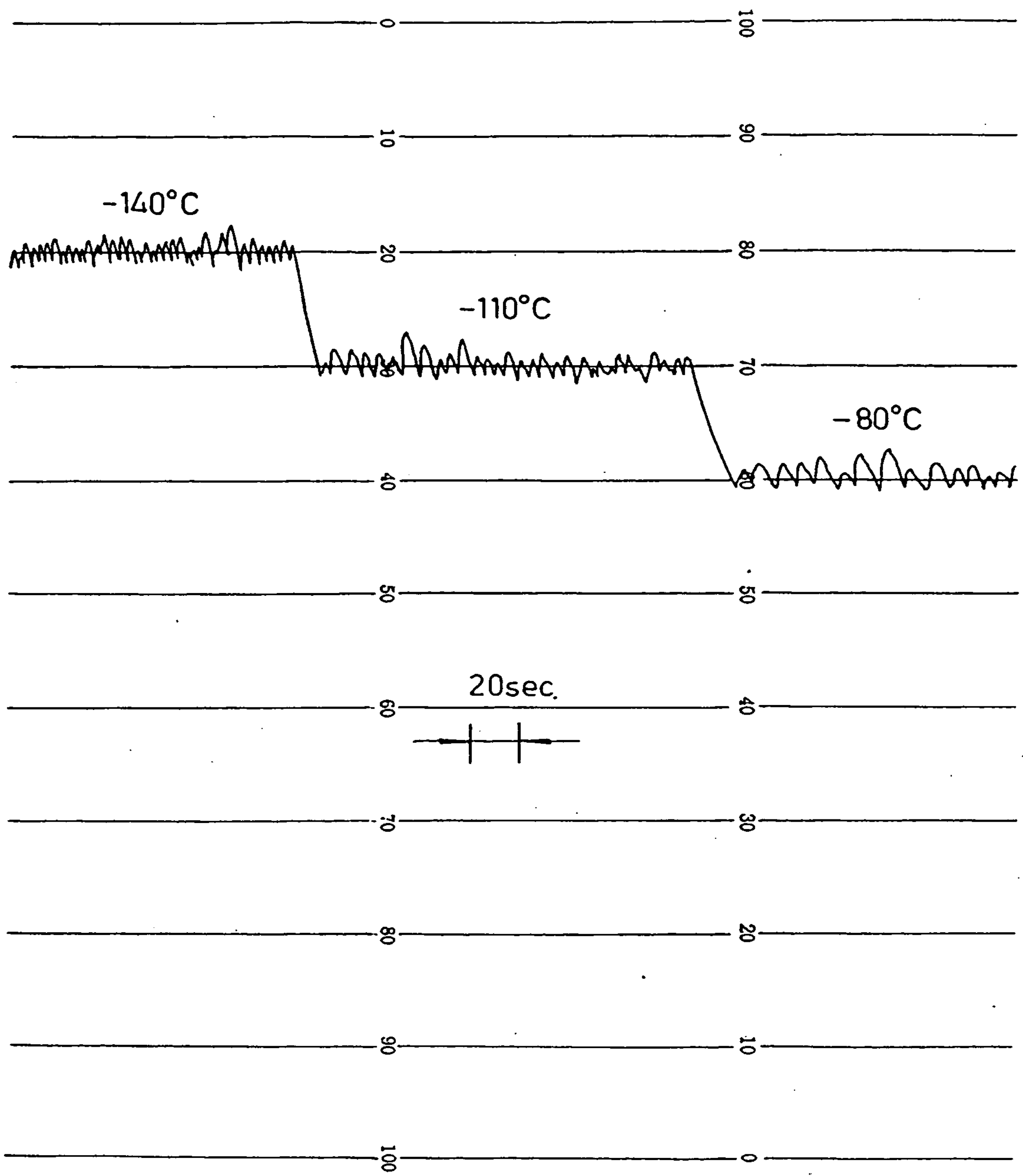

Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 20 0450

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-3 398 738 (LAMB ET AL.) * column 1, lines 55 - 72; column 2, line 26 - column 3, line 20; column 5, line 60 - column 7, line 36; figures 1, 3 * ---	1,2,9-11	G05D23/19 A61B17/36
A	US-A-3 782 386 (BARGER ET AL.) * abstract; column 1, line 58 - column 3, line 4; column 3, line 27 - column 5, line 11; column 6, line 25 - column 8, line 24; figure 1 * ---	1,2,12, 13	
X	FR-A-2 399 828 (VALLEYLAB) * page 1, line 26 - page 3, line 23; page 4, line 34 - page 5, line 7; page 8, line 9 - page 9, line 22; figure 2 * ---	1,2,11	
X	FR-A-2 207 730 (DRÄGERWERK AKTIENGESELLSCHAFT) * page 2, line 1 - page 3, line 1; page 3, line 14 - page 4, line 21; figures 1, 2 * ---	1,2,9-13	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US-A-3 823 575 (PAREL) * abstract; column 3, line 19 - column 4, line 2; column 5, line 40 - column 7, line 12; figures 1, 2, 6, 7 * ---	1,9-12	G05D A61B
A	US-A-4 946 460 (MERRY ET AL.) * abstract; column 4, lines 3 - 52; column 5, line24 - column 7, line 57; figures 1, 4-6 * ---	1,3,10, 12	
X A	WO-A-93 18714 (SMT SPOL. S. R. O.) * abstract; page 6, line 8 - page 9, line 12; figures 1, 2 * ---	1-5,11 12,13	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	30 January 1995	Beitner, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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